REMARKS

Claims 1-26 all the claims pending in the application. Claims 22-26 stand rejected upon informalities. Claims 1-26 stand rejected on prior art grounds. In addition, the drawings and specification are objected to. Applicants respectfully traverse these objections/rejections based on the following discussion.

I. The 35 U.S.C. ' 112, Second Paragraph, Rejection

Claims 22-26 stand rejected under 35 U.S.C. ' 112, second paragraph. The Examiner asserts that the meanings of terms "chlorine-type" and "fluorine-type" are unclear. The Specification at paragraph [0029] refers to reactive gas feedstocks containing less than 5% fluorine *based* reactants (i.e., reactants containing fluorine, e.g., CF_4, SF_6, NF_3, etc.) and the balance being chlorine or bromine *based* reactants (i.e., reactants containing chlorine or bromine, e.g., C_{l2}, BC_{l3}, HCl, HBr, Br_2, etc.) and possibly diluent gases. Claim 22 is amended accordingly. In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw this rejection.

II. The Prior Art Rejections

Claims 1-26 stand rejected under 35 U.S.C. ' 103(a) as being unpatentable over Rajeevakumar (U.S. Patent No. 5,283,453), in view of Diodato, et al. (U.S. Publication No. 2002/0079522), hereinafter referred to as Diodato. Claims 1-4 and 15-18 stand rejected under 35 U.S.C. ' 103(a) as being unpatentable over Rajeevakumar, in view of Alers. et al. (U.S. Patent 10/605,362

No. 6,750,495), hereinafter referred to as Alers. Applicants respectfully traverse these rejections based on the following discussion.

A. The Rejection of Claims 1-26 Based on Rajeevakumar and Diodata

Rajeevakumar discloses a trench sidewall structure and a method of forming and the trench sidewall. The method involves lining a trench with a titanium nitride diffusion barrier and filling the trench with a poly storage node 28 (see Abstract). The poly storage node 28 fills the trench and is recessed before an upper portion of the titanium nitride column is etched (see Col. 3, lines 31-37). Thus, the sides of the lower portion of the titanium nitride column is protected during the etching process and the top of titanium nitride is etched down level with the poly fill 28 within the trench (see Figures 5-6).

Diodato discloses a trench structure lined with titanium nitride 42 (see paragraph [0047] and Figure 1A). The titanium nitride liner 40 is "sized" (i.e., recessed) to form a gap 38 between the top of the titanium nitride liner and the top of the trench (see paragraph [0048]. To recess the titanium nitride liner 40, a photo resist layer is deposited into the trench and recessed down to a depth desired for the gap 38 (see paragraph [0049]). Then, "in the region free of the photoresist, an isotropic plasma etch then, removes the TiN layer from the widow 67" (see paragraph [0049]). The purpose of the photo resist in the trench is to protect the sides of the lower portion of the trench and in particular the sides of the lower portion of the titanium nitride trench liner from the "BCl_3 and CHF_3" that are used to etch the titanium nitride. After etching the titanium nitride, the photo resist is removed (see paragraph [0049]).

Regarding independent claims 1, 8, 15, and 22 the Examiner asserts that Rajeevakumar discloses forming a trench in a substrate; lining said trench with a polysilicon liner (see claims 15 and 22); forming titanium nitride columns in the trench; dry etching the titanium nitride columns using halogen-based gas phase chemistry to remove an upper portion of the titanium nitride columns; and filling a space between the titanium nitride columns and the upper portion of the trench with polysilicon material. However, contrary to the Examiner's assertions, Rajeevakumar does not teach the feature of claims 1, 8, 15 and 22 of filling a space *between the titanium nitride columns and the upper of the trench* with a polysilicon 30 (as illustrated in Figure 3D and described in paragraph [0025] of the present application) to form a cap in the trench. Rather, Rajeevakumar simply teaches filling in the space between the two titanium nitride columns 26 with a poly storage node 28 (see Figure 5), a polysilicon cap above the titantium nitride columns is not taught.

Additionally, regarding independent claim 1, the Examiner further asserts that Diodato discloses the additional feature of dry etching the titanium nitride columns using halogen-based gas phase chemistry that is substantially isotropic to remove an upper portion of said titanium nitride columns without affecting surrounding materials. Regarding independent claim 8, the Examiner further asserts that Diodato discloses the additional features of claim 8 of etching the titanium nitride columns using halogen-based gas phase chemistry that is substantially ion free to remove an upper portion of said titanium nitride. Regarding independent claim 15, the Examiner further asserts that Rajeevakumar in combination with Diodato teaches the additional feature of dry etching said titanium nitride columns using halogen-based chemistry that is substantially

isotropic to remove an upper portion of said titanium nitride columns without affecting said polysilicon liner, wherein said etching process attacks only in the uppermost portion of said titanium nitride columns such that, after said etching process is completed, the remaining lower portions of said titanium nitride columns are substantially unaffected by said etching process. Regarding independent claim 22, the Examiner further asserts that Rajeevakumar in combination with Diodato teaches the additional feature of dry etching said titanium nitride columns using halogen-based chemistry that is substantially ion free to remove an upper portion of said titanium nitride columns without affecting said polysilicon liner, wherein said halogen-based chemistry comprises 5%-95% of at least one of chlorine-based reactants and bromine-based reactants and less than 5% fluorine-based reactants. Thus, the Examiner asserts that Diodato teaches the feature of using halogen based chemistry that is substantially isotropic to remove an upper portion of said titanium nitride columns without affecting the surrounding materials, the remaining lower portions of the titanium nitride columns, or the polysilicon liner.

Contrary to the Examiner's assertions, Diodato does not teach using halogen-based gas phase that is substantially isotropic to remove an upper portion of said titanium nitride columns without affecting surrounding materials (claim 1), without affecting the polysilicon liner (claims 15 and 22), without affecting the lower portion of the titanium nitride columns (claims 15 and Claim 22 as amended), and without having to protect sides of the titanium nitride columns (amended claim 8). Rather, paragraph [0049] of Diodato simply discloses etching an upper portion of titanium nitride columns 40 using an isotropic plasma etch that "uses BCl_3 and CHF_3 and is performed at room temperature with no bias voltage." Because of the BCl_3 and CHF_3

halogen-based gas phase chemistry employed, the method disclosed specifically requires the use of a photo-resist layer (i.e., a protective mask) in the trench to *protect the surrounding materials,* and specifically, to protect sides of the titanium nitride columns. The claimed invention avoids the need to deposit a protective polysilicon plug or photoresist by using a halogen-based etching process that works without affecting the surrounding areas, such as the sides of the titanium nitride columns or the poly silicon liner (see paragraph [0025]). Furthermore, while Rajeevakumar mentions that a reactive ion etching using chlorine based chemistry may be used to etch titanium nitride (Col. 4, lines 13-15), neither Rajeevakumar nor Diodato specifically teach limiting the amount of fluorine used in the etching process.

Regarding each independent claim 1, 8, 15, and 22, the Examiner further asserts that it would have been obvious to one of ordinary skill in the art at the time the invention was made to etch said titanium nitride columns using halogen based chemistry that is substantially isotropic to remove an upper portion of said titanium nitride column *without affecting surrounding materials* (claim 1), *without affecting the lower portions of the titanium columns* (claims 15 and 22) and *without affecting the polysilicon liner* (claims 15 and 22) because Rajeevakumar teaches any known etching technique could be used to etch the titanium nitride and because Diodato teaches the method of removing the titanium nitride ensures electrical isolation from subsequently formed connections. While Rajeevakumar may have taught the use of any then "known" technique to etch titanium nitride, the applicant submits that the technique of the present invention was not known, nor was it obvious at the time of the invention. 35 U.S.C. §103(a) requires that the differences between the prior art and the subject matter sought to be patented are

such that the such that the subject matter as a whole would have *been obvious at the time the time the invention was made to a person having ordinary skill* in the art. MPEP 716.02 further provides that *an absence of an expected property is evidence of non-obviousness.* The etching processes used in both Rajeevakumar and Diodato require the deposition of a protective material (e.g., photoreist layer or other material) before etching the titanium nitride because the etchants and the techniques used are *expected* to result in the erosion of the lower portion of the titanium nitride columns. If the prior art techniques, as disclosed, were modified such that they were performed without a protective mask (e.g., a photoresist or polysilicon plug), they would be unsatisfactory for the intended purpose (see MPEP 2143.01) in that the lower portion of the titanium nitride columns and other surrounding materials would erode. However, the novel halogen-based isotropic etching process (e.g., performed using decoupling power source, bias of less than 100W, substantially ion-free and with chlorine or bromine-based reactants having less than 5% fluorine-based reactants) of the present invention allows for etching titanium nitride columns without affecting surrounding materials (claim 1), without affecting the polysilicon liner (claim 15 and amended 22), without affecting the lower portion of the titanium nitride columns (claim 15 and amended claim 22), and, thus, without having to protect sides of the titanium nitride columns (amended claim 8). Therefore, the Applicants submit that independent claims 1, 8 (as amended), 15 and 22 (as amended) are patentable over the cited prior art references.

Regarding dependent claims 2, 9, 16, and 23, the Examiner asserts that Rajeevakumar teaches said process of filling said space simultaneously forms a polysilicon plug and polysilicon cap. As discussed above, Rajeevakumar simply teaches filling the space between the two

titanium nitride columns and does not teach forming a polysilicon cap above the titanium nitride columns (i.e., between the titanium nitride columns and the upper of the trench).

Regarding independent claim 22 and dependent claims 3, 4, 10, 11, 17, and 18 the Examiner asserts that Rajeevakumar and Diodato combined disclose the method wherein said halogen based chemistry has less than 5% fluorine or is substantially fluorine free. As mentioned above, while Rajeevakumar teaches that a reactive ion etching using chlorine based chemistry may be used to etch titanium nitride (Col. 4, lines 13-15), neither Rajeevakumar nor Diodato specifically teach limiting the amount of fluorine to be used in the etching process.

Regarding dependent claims 5, 6, 12, 13, 19, 20, 24 and 25, the Examiner asserts that Rajeevakumar and Diodato combined teach using a decoupled power source either with a bias power of less than 100W or a bias power of less than 100W (citing Diodato paragraph [0049]. While Diodato mentions performing the etching process "with no bias voltage", neither Rajeevakumar nor Diodato teach using a decoupled power source.

Claims 2-7 depend from claim 1, incorporate the same distinguishing features and are likewise patentable over the cited prior art. Claim 2-6 are also patentable because of the additional distinguishable features of the invention which they define. Claims 9-14 depend from claim 8, incorporate the same distinguishing features and are likewise patentable over the cited prior art. Claims 9-13 are further patentable because of the additional distinguishable features of the invention which they define. Claims 16-21 depend from claim 15, incorporate the same distinguishing features and are likewise patentable over the cited prior art. Claim 16-20 are also patentable because of the additional distinguishable features of the invention which they define.

Claims 23-26 depend from claim 22, incorporate the same distinguishing features and are likewise patentable over the cited prior art. Claim 23-25 are also patentable because of the additional distinguishable features of the invention which they define. .In view of the foregoing, the Examiner is respectfully requested to reconsider and withdraw his rejection.

B. The Rejection of Claims 1-4 and 15-18 Based on Rajeevakumar and Alers

Alers is referenced by the Examiner for the limited purpose of showing a method of dry etching said titanium nitride columns using halogen-based gas phase chemistry that is substantially isotropic to remove an upper portion of said titanium nitride columns without affecting surrounding materials (claim 1) and without affecting the polysilicon layer or the remaining lower portion of the titanium nitride columns (claim 15). The Examiner further asserts that it would have been obvious to one of ordinary skill in the art at the time the invention was made to etch said titanium nitride columns using halogen based chemistry that is substantially isotropic to remove an upper portion of said titanium nitride column without affecting the layers below (i.e., *without affecting surrounding materials* (claim 1) and *without affecting the lower portions of the titanium columns or the polysilicon layer* (claim 15)) because Rajeevakumar teaches any known etching technique could be used to etch the titanium nitride and because Alers teaches the method of removing the titanium nitride ensures electrical isolation from subsequently formed connections.

However, Alers simply discloses a capacitor structure that is formed in a trench with a titanium nitride electrode 102 lining the trench (i.e., window101) but leaving an upper portion 204 of the trench sidewall exposed (see Figure 2 and Col. 3, lines 33-44). The disclosed

technique used to etch back the titanium nitride is to fill the trench with a suitable photoresist after the deposition of the lower electrode layer and to carry out a blanket photoresist removal or etchback (e.g., by plasma removal) (see Col. 4, lines 12-17). The photoresist layer protects the lower portion of the titanium nitride columns. As discussed above, while Rajeevakumar may have taught the use of any then "known" technique to etch titanium nitride, the applicant submits that the technique of the present invention was not known, nor was it obvious at the time of the invention. The etching processes used in both Rajeevakumar and Alers require the deposition of a protective material (e.g., photoresist or other material) before etching the titanium nitride because the etchants and the techniques used are *expected* to result in the erosion of the lower portion of the titanium nitride columns. If the prior art halogen-based techniques, as disclosed, were performed without a protective plug they would be unsatisfactory for the intended purpose (see MPEP 2143.01) in that the sides of the titanium nitride columns and other surrounding materials would erode. However, the novel halogen-based isotropic etching process (e.g., performed using decoupling power source, bias of less than 100W, substantially ion-free and with chlorine or bromine-based reactants with less than 5% fluorine-based reactants) of the present invention allows for etching titanium nitride columns without affecting surrounding materials (claim 1), without affecting the polysilicon liner (claim 15 and amended 22), without affecting the lower portion of the titanium nitride columns (claim 15 and amended claim 22), and, thus, without having to protect sides of the titanium nitride columns (amended claim 8). Therefore, the Applicants submit that independent claims 1 and15 are patentable over the cited prior art references.

Regarding dependent claims 2 and 16, the Examiner again asserts that Rajeevakumar teaches said process of filling said space simultaneously forms a polysilicon plug and polysilicon cap. As discussed above, Rajeevakumar simply teaches filling the space between the two titanium nitride columns and does not teach forming a polysilicon cap above the titanium nitride columns (i.e., between the titanium nitride columns and the upper of the trench). Thus, claims 2 and 16 are patentable not only because they depend from patentable independent claims 1 and 15, respectively, but because of the additional distinguishable features which they define.

Additionally, regarding dependent claims 3, 4, 17, and 18 the Examiner asserts that Rajeevakumar and Alers combined disclose the method wherein said halogen based chemistry has less than 5% fluorine or is substantially fluorine free. While Rajeevakumar mentions that a reactive ion etching using chlorine based chemistry may be used (Col. 4, lines 13-15), neither Rajeevakumar nor Alers specifically teach limiting the amount of fluorine. Thus, claims 3, 4, 17 and 18 are patentable not only because they depend from patentable independent claims 1 and 15, respectively, but because of the additional distinguishable features which they define.

III. Formal Matters and Conclusion

With respect to the objections to the specifications, the specification has been amended, above, to overcome the objection. With respect to the objection to the drawings, Replacement Sheets are submitted herewith. Thus, the Examiner is respectfully requested to reconsider and withdraw the objections to the specification and drawings.

In view of the foregoing, Applicants submit that claims 1-26, all the claims presently

pending in the application, are patentably distinct from the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary.

Please charge any deficiencies and credit any overpayments to Attorney's Deposit Account Number 09-0458.

Respectfully submitted,

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